by Bruce A. Bergman

Process Improvements

This month, I'm going to get off track a bit and write about engineering process improvements, a topic that many people are interested in, yet is still somewhat of a black hole. Instead of the in-depth discussion that should take place, I'll just give an overview of the topic and if you feel that you would like to hear more about it, please let me know.

Engineering process improvements are tangible activities that engineering departments can perform that *should* improve productivity and products. In other words, if done correctly, the engineers in that department should become more productive, more efficient, more knowledgeable, and, at the same time, contribute to the overall success of the department by producing items that work better, read better, and so on. I use the word "items" loosely because engineering process improvements are not limited to software, although that application is the most common. They can be applied to documentation, hardware, and so on. The end result, which is to improve upon what existed before, should be the same. The engineering process, a catchall for the activities from conception to completion, can always be improved.

Engineering process improvements are not a new topic in Computer-Science Land. Scientists have been working on these improvements since day one, and much of the benefit we enjoy today is because of the years of research they have done within their own engineering departments. The overall concept is simple. Implementing it *successfully* is not. The years have shown this fact over and over, and, hopefully, we can learn from scientists who have taken the rough road.

SIMPLE ENHANCEMENTS

Generally speaking, process improvements address several different thrusts at engineering activities. Some of the more common improvements to be implemented include requirements reviews, design meetings, coding guidelines, style guidelines, code inspections, tiered testing, and product verification.

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The one thing these improvements have in common is that they look easy to implement but, in reality, can often be nightmares. For example, take style guidelines. Most engineers have developed their own style for coding or writing, and to be given a document describing, in minute detail, exactly where all those matching braces should be placed is tantamount to asking for hate email to come flooding through your network.

In general, process improvements would be manifested under the greater umbrella of quality assurance. In small companies, however, quality assurance is often an activity that is done by no one and yet by everyone. Either way, these improvements can be implemented successfully by any company.

REQUIREMENTS AND DESIGN

It is important to match a customer's requirements with the potential for completion by the engineering department. We do this with a requirements review. Basically, this means reviewing a list of requirements and deciding if meeting those requirements is feasible. Some engineering departments like to assign a level-of-effort value to each requirement to develop a good picture of the overall project. Some engineering activities may not have requirements reviews at all.

Design meetings are used in the early stages of the development cycle to attempt to catch design flaws, plan future action, identify the development course, and so on. These design meetings come in a variety of flavors and can be as structured as the preliminary and critical design reviews, or as unstructured as an informal meeting of the designer and a couple of engineers. Studies show that if design meetings are held before moving on to later stages in the development cycle, as many as 85% of all problems can be found.

Design meetings should be held at least twice during the design cycle: before the design begins and after the design has been completed. Of course, *all* design meetings held between these points decrease the chance of significant rework if a problem is identified. At the first design meeting, participants should identify the goal of the design. What is the ultimate product of the design? What should be produced after the design is done? When the goal is clear, the participants should identify potential problem areas, brainstorm for ideas, and so on. The participants should refrain from trying to solve the problems or do the actual design. The idea behind this first meeting is to plot future courses of action.

Later meetings should be used to present a part of the design or address specific concerns that come up during the design process. Ultimately, when the design is done, review the entire design for omissions, problems, complete-

ness, and so on. Perhaps a check against the requirements matrix is needed.

The next stage is to do the actual work, which, in the software context, means coding. In the hardware context, it might mean actually building the product. In a documentation context, it might be writing a user's guide. Regardless of what it is applied to, this stage of the development can apply other engineering process improvements that have been developed. That same technical writer who is about to embark on creating the user's guide can apply the style guidelines that have been developed to produce documentation that meets the department's standards.

One important aspect at this stage of development is the implementation of code inspections or reviews. Again, I'll talk about this concept in the software context, but it is just as applicable elsewhere. In fact, the person credited for the creation of this concept is Michael

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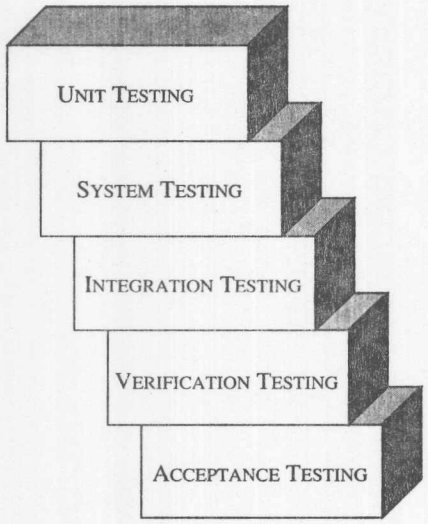
Fagan, who was working for IBM back in the mid-1970s. While code inspections today are used primarily for software, Fagan intended his concept to be used on hardware. Reviews can be helpful in several areas of software or hardware.

CODE INSPECTIONS

Code inspections and peer reviews can be divided into two categories: code reviews and code walk-throughs. The primary difference is the level of formality. Code reviews are intended to be formal, held at logical transition points in the development cycle, and provide metrics for the object being reviewed. Code walk-throughs are less formal and are meant to touch base with other developers and individuals to get a feel for how the project is progressing.

Some of the benefits of code reviews are that they assist in the transfer of knowledge from engineer to engineer. They also allow for more accurate project schedules and estimations, provide metrics for problem analysis, product development, and so on. Similar to design meetings, code reviews are held with others in attendance, a specific goal for the meeting, a predetermined list of invitees, and an exit criteria. After each review, and especially if it is a formal review, the group should decide on an exit criteria. That is, should the development continue? Are there minor problems that should not hold up devel-

Figure 1
Tiered testing.



opment, but that should be fixed? Or are there major problems that need to be addressed before continuing? Engineers who participate in code inspections are more than twice as efficient as they would be if they found the same problems in later stages such as unit testing.

Remember, these meetings should not be used to solve problems. Rather, they should be used to *identify* problems. If this focus is kept, the meetings go much more smoothly.

TESTING

Tiered testing is an important part of any engineering process. The idea behind tiered testing is to divide testing into several distinct phases that complement and overlap each other to some degree. If done properly, this method produces a tiered effect, as shown in Figure 1.

At the earliest stage, unit testing is done on some small, logically removed unit of the finished product. In software, this unit might be a module, package, or reusable object, while in larger interests, a unit might be a component of the final product. The idea is to apply a set of limited (but extensive) tests to one small part while exercising as much of the unit as possible. Any problems encountered can be dealt with at the unit level.

In system testing, a larger group of units are tested together to make sure they work well as a group. This form of testing is helpful in identifying intermodule problems, interface problems, and so on. This type of testing is slightly different from integration testing, which really should be done on a larger scale. Integration testing, for instance, might test the way two components act when they are used together, which should identify problems such as where your standard output went if it didn't make it through the pipe successfully. ("It goes to never-never land....")

Verification testing is used to show that the finished product does what it was intended to do. This stage of testing can be done when the product, as a whole, is finished and ready to ship. A logical part to review in this stage is the installation procedure. If a customer re-

ceives a piece of software or hardware that can't be installed the way the documentation *says* it can, then verification testing was either omitted or done poorly.

Lastly, acceptance testing is a formal activity that seeks to prove that all requirements have been met. If the requirements review process is done properly, a requirements matrix should have been developed. This matrix is used in conjunction with specific tests to prove that the product performs as anticipated. This type of testing is wide ranging and might include hardware, software, and documentation. It might also include performance tests, visual inspections, assumed or implied completions, and so on.

The entire concept of engineering process improvements is exactly what the name says: to improve the engineering process. Improvements are achieved by applying logical and intelligent controls and checks to existing development or new development. If everything is done correctly and instituted with respect for the individuals involved, the benefits should be self-evident after a period of time.

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If you would like to learn more about engineering process improvements or if you have successful ideas from your own organization, please drop me a line and let me know what you think. Opinions, tips, or suggestions can be sent to Embedded Systems Programming, 600 Harrison St., San Francisco, Calif. 94107, or use the Embedded Systems Programming Bulletin Board System at (415) 905-2689. We prefer tips to be as machine-independent as possible and primarily in C, Ada, Forth, or assembly language. Contributions I use will be published with appropriate credit and a small, but heartfelt, honorarium.

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